Simulation-based PSHA for the Canterbury region (Cybershake v17.8)

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1. Introduction

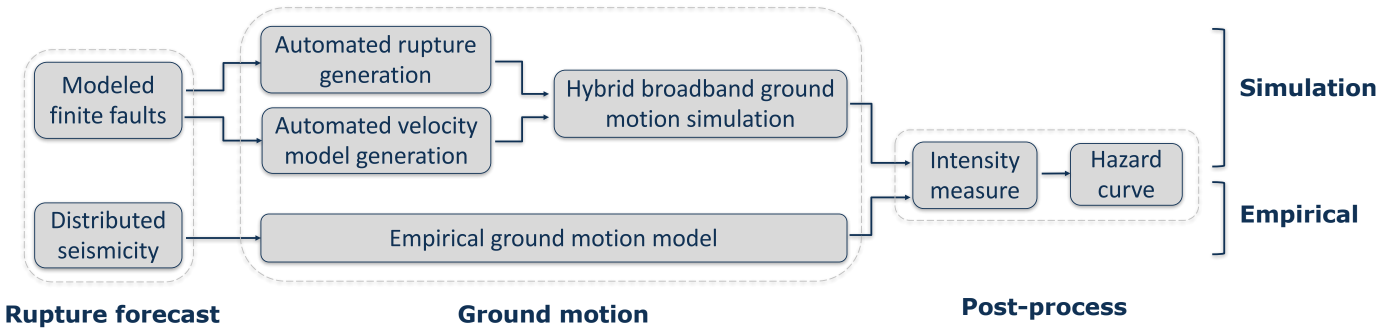
This poster presents the computational components of physics-based broadband ground motion simulations to perform probabilistic seismic hazard analysis (PSHA) for Canterbury, New Zealand. Ground motions are simulated using the hybrid broadband simulation approach of Graves and Pitarka (2010, 2015). The workflow for the nation-wide simulation-based PSHA (i.e., NZ Cybershake) comprises three components:

I. Automated rupture generation based on 2010 National seismic hazard model for New Zealand (Stirling et al 2012).
II. Automated velocity model generation based on the rupture size and optimization of the land coverage.
III. Running simulations for different realizations of considered sources and post-processing of the results to obtain hazard curves.

The simulation based seismic hazard analysis is pioneered by the Southern California Earthquake Centre (SCEC) (Graves 2011). Current efforts for New Zealand consider different approaches in four aspects compared to SCEC's workflow:

I. Forward simulation is utilized compared to the reciprocity approach used in the SCEC Cybershake.
II. Automated velocity model generation specific to each scenario rupture, considering maximizing the land coverage of the domain by rotating and reducing the initial domain size.
III. Simulations are post-processed on a non-uniform grid, generated based on the nation-wide population density and local site conditions.
IV. Sources from the distributed seismicity model are incorporated into the hazard calculation using an empirical ground motion model.

Figure 1 outlines the computational components of the NZ Cybershake project:



$$\lambda_{Rup}(rup_n) \qquad P_{IM|Rup}(IM > im|rup_n) \qquad \lambda_{IM}(im) = \sum_{n=1}^{N_{rup}} P_{IM|Rup}(IM > im|rup_n)\,\lambda_{Rup}(rup_n)$$

Figure 1: Computational workflow of New Zealand Cybershake.

2. Automated rupture generation

Figure 2a-b presents 15 and 110 finite faults considered for v17.8 and v17.9 versions of Canterbury Cybershake. Deaggregation of the PSHA results based the empirical ground motion model of Bradley (2013) was utilized to identify dominant sources in the region from modelled faults.

Variation in two important source parameters are considered in generating the kinematic ruptures on the faults:

I) Slip distribution, II) hypocentre location.

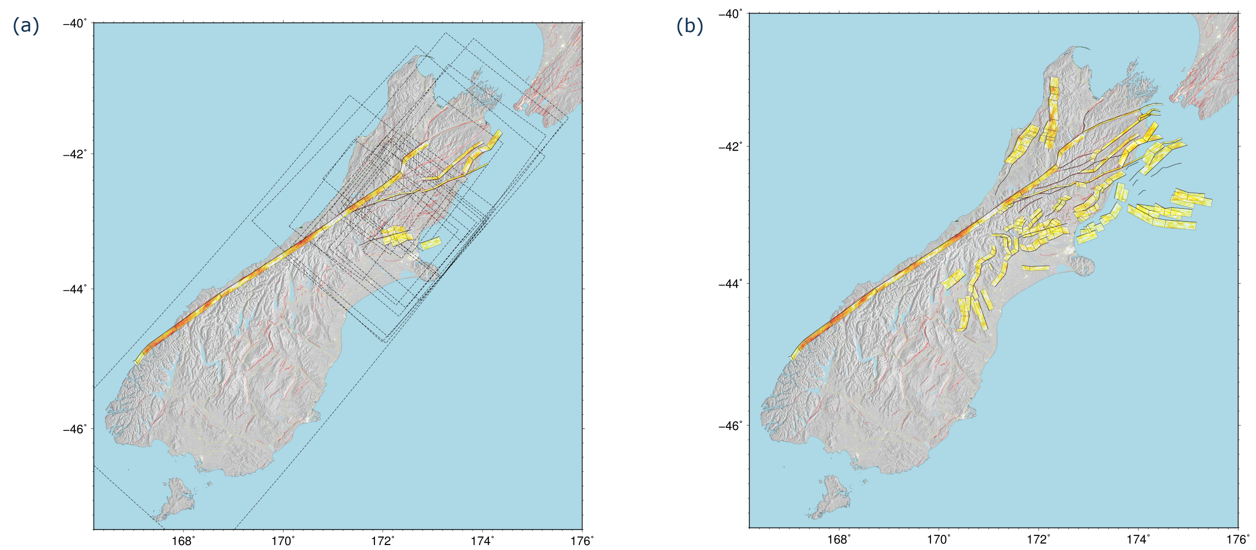


Figure 2: Scenario ruptures considered for the physics-based simulations: (a) 15 faults and their corresponding velocity model domains for v17.8 preliminary simulations; (b) 110 sources for v17.9 simulations.

3. Automated velocity model generation

Velocity models are generated in an automated fashion for sources in the New Zealand national seismic hazard model (Stirling et al 2012), based on three criteria:

I) Size of the rupture.
II) Distance to PGV of 2 cm/s based on the Bradley (2013) empirical ground motion model.
III) Rotation and reduction of the initial domain to maximize the land to ocean ratio.

Figure 3 illustrates the initial and final velocity model domains for three sources considered with different size and locations.

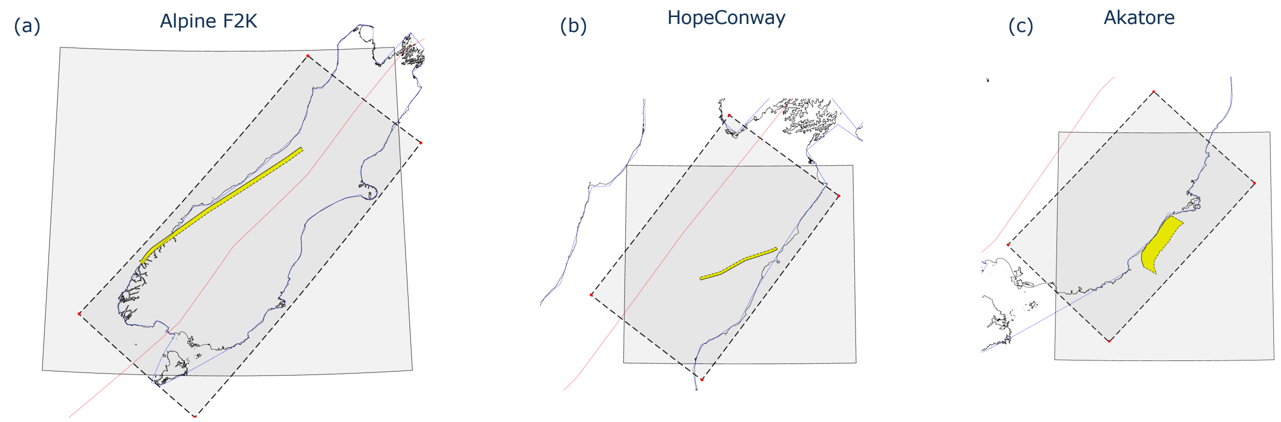


Figure 3: Automated velocity model generation: (a) Alpine F2K; (b) HopeConway; and (c) Akatore.

4. Post-processing of simulated ground motions

In order to reduce the computational burden of simulations using a uniformly fine grid, a non-uniform grid is utilized, created based on the population density in different parts of the country (see Figure 4a).

In addition, regions on soft sedimentary basins have a denser grids, in order to investigate the variations in the local ground motion properties due the change in the local site conditions.

Figure 4b presents the results of simulations for a realization of the AlpineF2K scenario rupture considered in the preliminary Cybershake runs (v17.8). The simulated ground motions can represent the specific features of the rupture hypocentre location and slip distribution utilized, as apposed to the simplified representation in empirical ground motion models (i.e., magnitude).

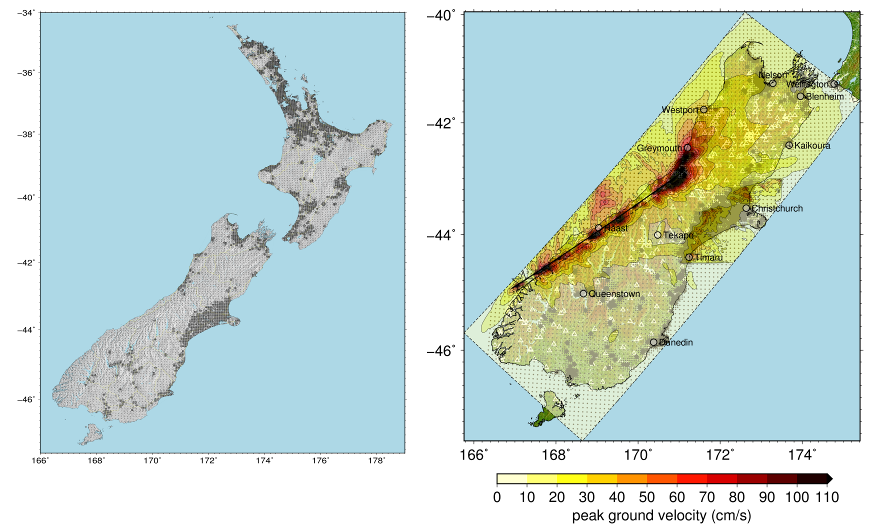


Figure 4: (a) Non-uniform post-processing grid; PGV of AlpineF2K simulation.

5. Next Steps

- Number of the considered sources will be increased for the next versions of NZ Cybershake, to ultimately include all the finite faults in the New Zealand national seismic hazard model (Stirling et al 2012).
- Number of hypocentre realizations and slip distributions will be increased.
- Simulations will be run at a finer grid to increase transition frequency.

Version	Number of sources	Rupture variation	Velocity model	Simulation specs	Estimated core hours
v 17.8	15	3 Hypocenter 2 slip distributions	0.4km regular grid, Vsmin=500 m/s	0.25Hz transition Frequency	3,000
v 17.9	110	Length-dependent hypocenter, 2 slip distributions	As for v 17.8	As for v 17.8	30,000
v 17.10	110	Length-dependent hypocenter, 10 slip distributions	0.2km regular grid, Vsmin=500 m/s	0.5Hz transition Frequency	170,000
v 17.11	540	As for V 17.10	As for v 17.10	As for v 17.10	500,000